Potential Biological Control of Weeds in Rice Fields by Allelopathy of Dwarf Lilyturf Plants

Abstract

Medicinal plants have been a cornerstone of cultivation in every culture around the world for many millennia. The intention of this paper is to explore the potential of Dwarf Lilyturf (*Ophiopogon japonicus*), a well known and celebrated medicinal plant in Traditional Chinese Medicine, as a possible herbicide for common weeds in rice patties. Aqueous solutions drawn from a dried powder of the underground components of the plant significantly reduced the germination of Monchoria (*Monocharia vaginalis* P.) and smallflower umbrella (*Cyperus difformis* L.) but had less effect on barnyardgrass (*Echinochloa crusgalli* L.). Barnyard grass, at lower concentrations, actually saw increased growth. The application of dry powder in a greenhouse setting had a similar effect as the aqueous solution. There was no negative effect of the application of the powder on the rice plants. All credit for data and knowledge on this academic poster is credited to Dongzhi Lin, Eiji Tsuzuki, Yanjun Dong, H. Terao and T.D. Xuan

Introduction

It is well understood that plants create compounds that restrict the growth of competing plants. It has been shown that many different compounds are used, but all are used to the same ends (D. T. Patterson, 2020). These compounds, known as allelopathic chemicals, have been proven to be very effective as an entirely natural herbicide. This potential for novel and natural pesticides is important as synthetic pesticides continue to prove to be more environmentally costly and become harder to develop. These compounds have been tested mostly in plants which have major agronomic implications (Brassicas and alfalfa) or are weeds competing with the intended crop (Rehman, 2019).

However these explorations have left out medicinal and herbal plants. These plants are generally of extreme social and cultural importance and are known to contain many compounds. This leaves much potential for the creation of an effective and safe control for weeds in field applications.

The intention of this research is to explore the use of the root portions of Dwarf Lilyturf, a well known medicinal plant used in Traditional Chinese Medicine. The common rice paddy weeds (*Monocharia vaginalis* P.), smallflower umbrella (*Cyperus difformis* L.), and barnyard grass (*Echinochloa crusgalli* L.) will be tested on along with rice plants to ensure their growth is not also affected.

Image 1: Dwarf Lillyturf with flowers

Image 2: Smallflower Umbrella

Method

The experiment began with the creation of a dry powder made of the underground portion of the Dwarf Lilyturf. The roots and nodules were dried at 50 degrees C for 48 hours and then chopped and ground into powder which was stored at -20 degrees C. For the intentions of the research the experiment was split into two test groups, one using an aqueous solution and the other using ground dried powder.

Within the dried powder test group the powder was applied directly in two separate setups. One was weeds in rice paddy soil extracted from a field and the other on 1 month old rice plants also taken from a field. Soil was extracted to a depth of 10 cm in a rice patty. The soil was dried in a greenhouse for a month and placed into three 18 inch diamber Wagner pot. The soil was irrigated with tap water then after 4 days a test of 50, 100, and 150 g/m^2 was applied to the each pot respectively. Each treatment and a control was done in triplicate and were randomized. The 1 month old rice plants were tested similarly with 4 plants per pot being given 4 days after transplanting before the application of 50, 100, or 150 g/m^2. Each treatment and control were done in triplicate and randomized. The rice was grown for 25 days before data was collected.

The aqueous solution was created by soaking one, two, four or eight grams of dried powder in 100 ml of water and stored at five degrees C. The aqueous solutions was applied to seeds of barnyardgrass, monchoria, and smallflower umbrella seeds in glass petri dishes. The petri dishes were stored in growth chambers with 12 hours of light at 25 degrees C. Barnyard germination and growth was measured after 5 days, and the others were measured after 10.

Results

Table 1. Effects of aqueous extracts from the dried underground parts of dwarf lilyturf on germination and growth of the three main weed species in rice fields

Concentrations (w/v,%)	Germination (%)	Shoot (mm)	Root (mm)
Monchoria (*Monocharia vaginalis* P.)			
0	70.0 (0)[1]	9.65 (0) a[2]	16.14 (0) a
1	63.3 (9.6)	5.53 (42.7) b	2.50 (71.3) b
2	18.7 (73.3)	4.64 (51.9) b	0.69 (95.7) c
4	0 (100)	0 (100) c	0 (100) d
8	0 (100)	0 (100) c	0 (100) d
Barnyardgrass (*Echinochloa crusgalli* L.)			
0	100 (0)	25.18 (0) a	20.47 (0) a
1	100 (0)	31.98 (–27.0) bc	37.02 (–80.9) b
2	100 (0)	30.41 (–20.8) dc	25.48 (–24.5) c
4	100 (0)	24.67 (2.0) ae	5.97 (70.8) d
8	92.2 (7.8)	18.65 (25.9) f	2.02 (90.1) e
Smallflower umbrella (*Cyperus difformis* L.)			
0	85.1 (0)	4.18 (0) a	2.92 (0) a
1	67.5 (20.7)	2.86 (31.6) b	0.53 (81.5) b
2	41.7 (51.0)	2.54 (39.2) c	0.69 (76.4) b
4	0 (100)	0 d (100) d	0 (100) c
8	0 (100)	0 d (100) d	0 (100) c

[1]Numbers in parentheses are the inhibition percentage (%) compared with respective controls.
[2]Values with the same letters within a column are not significantly different at the 0.05 probability level determined by least significant difference (LSD).

Table 2. Effects of the dried powders from underground parts of dwarf lilyturf on emergence and growth of all weeds in rice paddy soil

Weeds	Treatment concentrations (g m^{-2})			
	0	50	100	150
Emergence of weed seedlings (no./pot)				
Barnyardgrass	22.33 (0) a[1]	24.67 (–10.5) a[2]	17.67 (20.9) a	9.33 (58.2) b
Non-barnyardgrass	305.00 (0) a	115.67 (62.3) b	99.67 (67.7) b	63.33 (79.2) b
Total	327.33 (0) a	140.33 (57.1) b	117.33 (64.4) bc	72.66 (77.6) c
Dry weight of weed seedlings (g/pot)				
Barnyardgrass	0.536 (0) a	0.398 (25.8) a	0.211 (64.5) b	0.021 (96.1) c
Non-barnyardgrass	0.423 (0) a	0.212 (49.5) b	0.194 (53.6) b	0.064 (84.5) c
Total	0.959 (0) a	0.610 (36.4) b	0.406 (57.7) c	0.085 (91.1) d

[1]Numbers in parentheses are the inhibition percentage (%) compared with respective controls.
[2]Values with the same letters within a row are not significantly different at the 0.05 probability level determined by least significant difference (LSD).

Table 3. Effects of the dried powders from underground parts of dwarf lilyturf on barnyardgrass seedlings and rice plants

Traits	Treatment concentrations (g m^{-2})			
	0	50	100	150
Barnyardgrass				
Plant height (cm)	32.99 (0) a[1]	27.85 (15.6) b[2]	21.05 (36.2) c	17.86 (45.9) c
Root length (cm)	13.61 (0) a	12.25 (10.0) a	7.24 (46.8) b	4.59 (66.3) c
Rice				
Plant height (cm)	34.58 (0) a[1]	33.04 (4.5) a[2]	34.78 (–0.5) a	33.5 (3.1) a
Tiller (no./plant)	15.96 (0) a	17.50 (–9.6) b	18.09 (–13.3) b	17.2 (–7.8) ab

[1]Numbers in parentheses are the inhibition percentage (%) compared with respective controls.
[2]Values with the same letters within a row are not significantly different at the 0.05 probability level determined by least significant difference (LSD).

- Germination and growth of monchoria and smallflower umbrella were both reduced to zero by six and eight percent concentrations of aqueous solution and reduced by 36-91 percent by the dried powder application
- Germination and growth of barnyardgrass was marginally increased by lower concentrations of the aqueous and powder treatments and marginally decreased and notably decreased by higher concentrations of the aqueous and powder treatments respectively.
- The rice tillering and height did not seem to be affected in any major way which could be definitively connected to the powder treatment.

Conclusion

The results of the test shows definitely that there is great potential in the use of medicinal plants in the development of novel and sustainable herbicides. Not only did it suppress much of the potential biomass produced by these common weeds in rice patties, it also did not negatively affect the growth of the rice crop. This is not to say there is not more to be known. While monchoria and smallflower umbrella were both controlled effectively with both application methods, barnyardgrass was only marginally controlled. This leaves room for improvement and better understanding in why this grass was unaffected by the compounds and, maybe more importantly, exploration into other medicinal plants or allelopathic compounds which can control barnyardgrass or other monocots in fields.

Image 3: Common Barnyardgrass is one of the most insidious and common agricultural weeds. It is host to many mozaic viruses and can remove up to 80 percent of all available nitrogen in the soil. It propagates itself aggressively by seeds and by node cuttings

Image 4: Monochoria flower is native to most of Asia. In the United States it is considered to be noxious and invades aggressively into aquatic areas. As an agronomic weed they are found in rice paddies and can cause serious competition to the crop.

Citations

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